Status of Emission Control on Wärtsilä 2-stroke Sulzer RTA engines

Maritime Air Quality Technical Working Group

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IMO NO_x regulation

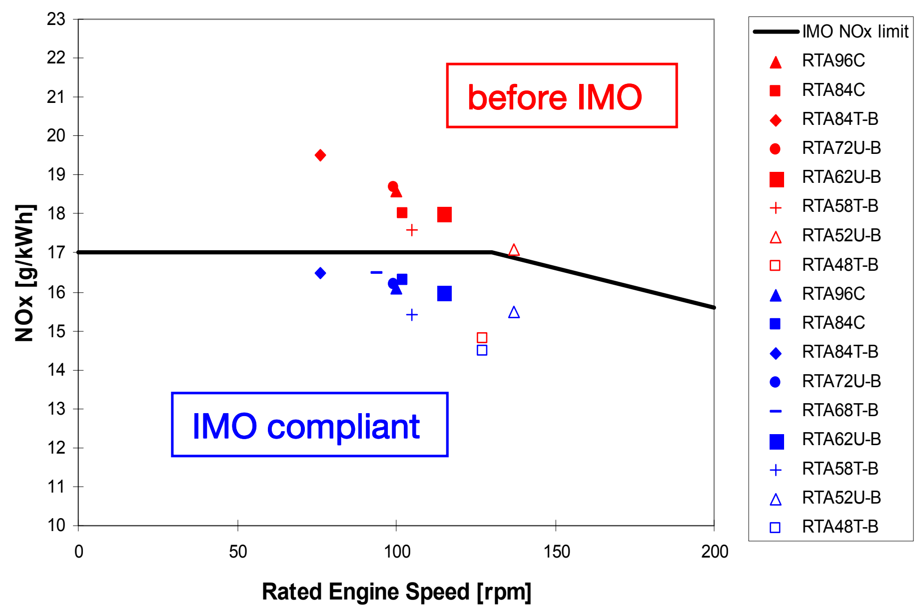
Actual status:

All Sulzer RTA and RT-flex engines (approx. 200) installed on ships with keel-laying on or after the January 1st, 2000 comply with Regulation 13 of Annex VI to MARPOL 73/78 by the application of the so-called:

Low NO_X Tuning

The elements are:

- Increased compression ratio
- Injection delay
- Changed exhaust valve timing



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Future NO_X reducing technology

Further NO_X reduction measures:

- **Engine tuning**

  Measures as higher compression ratio and optimization of fuel injection have already been stressed out in order to comply with the Annex VI limits.

- **EGR**

  Applicable only in combination with 'clean fuels' (corrosion and fouling problems when running with residual fuel).

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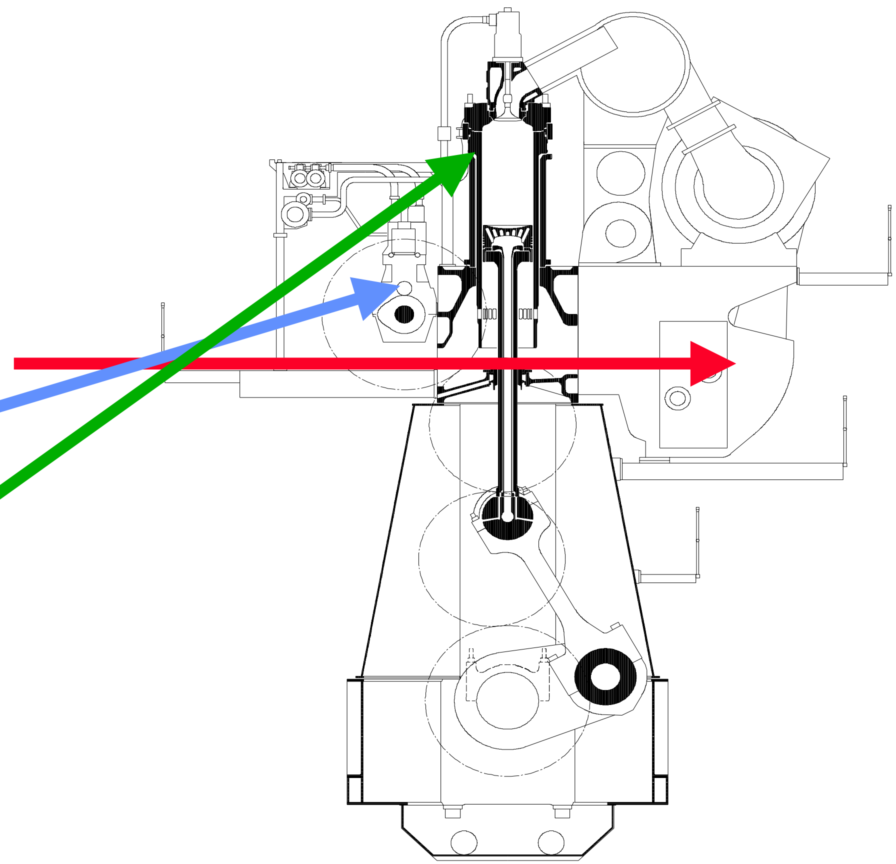
Future NO_X reducing technology

Further reduction of NO_X emissions :

Water addition

- Humidification of intake air
- Fuel/water emulsion
- Direct water injection



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Future NO_X reducing technology

Note: All methods using water require high amounts of water, which might not be available at low loads (produced by fresh water generators) or in coastal regions (sea water quality).

Humidification of intake air

Water injected into compressed scavenge air

+ simple system

- high amount of water amount (up to 2 times of fuel amount)
- affecting oil film??

Note: Not yet tested on 2-stroke Sulzer RTA engines

Future NO_X reducing technology

Fuel/water emulsion

Water mixed to fuel in emulsifyer (load-dependent)

+ simple system, if not high water amounts at 100% load required
- limited due to capacity of fuel pump, heating temperature of fuel system and stability of emulsion
- cavitation fuel pump??

Note: Some experience on stationary 2-stroke Sulzer engines with 'low' water amounts (15-18%).

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Future NO_X reducing technology

Direct water injection

Water injected by a second, fully independent injection system

+ flexible timing

+ higher water amount can be injected (up to 70% of fuel amount)

- additional equipment (pump, pipes, rail, injectors)

- long-term behaviour??

Note: Tested on 2-stroke R&D engine on testbed at the moment

(for Wärtsilä 4-stroke engines already available)

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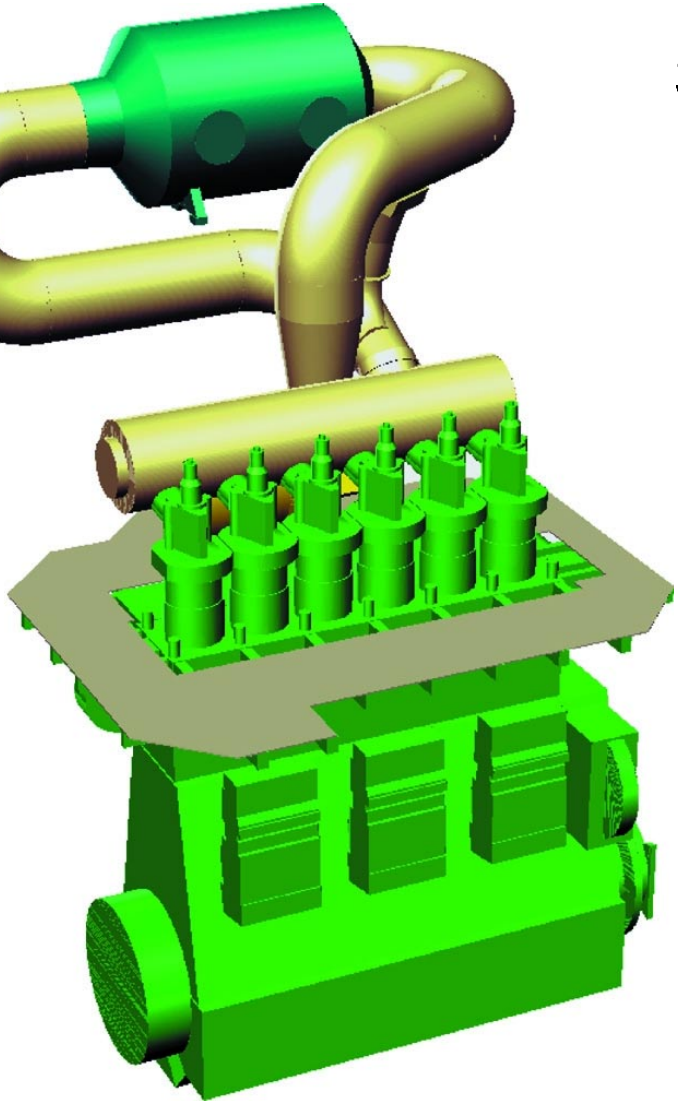
Selective Catalytic Reduction

Sulzer 6RTA52 with SCR system



SCR state of the art:

- Exhaust gas temperature
  ≈ 350°C ⇨ before T/C
- Urea consumption
  ≈ 25 l / MWh
- NOx reduction
  ≥ 90% ⇨ ≤ 2 g/kWh
- Investment costs
  40'000-60'000 US$ / MW
- Running costs (urea)
  ≈ 3.75 US$ / MWh
- Maintenance costs
  ≈ 0.9 US$ / MWh

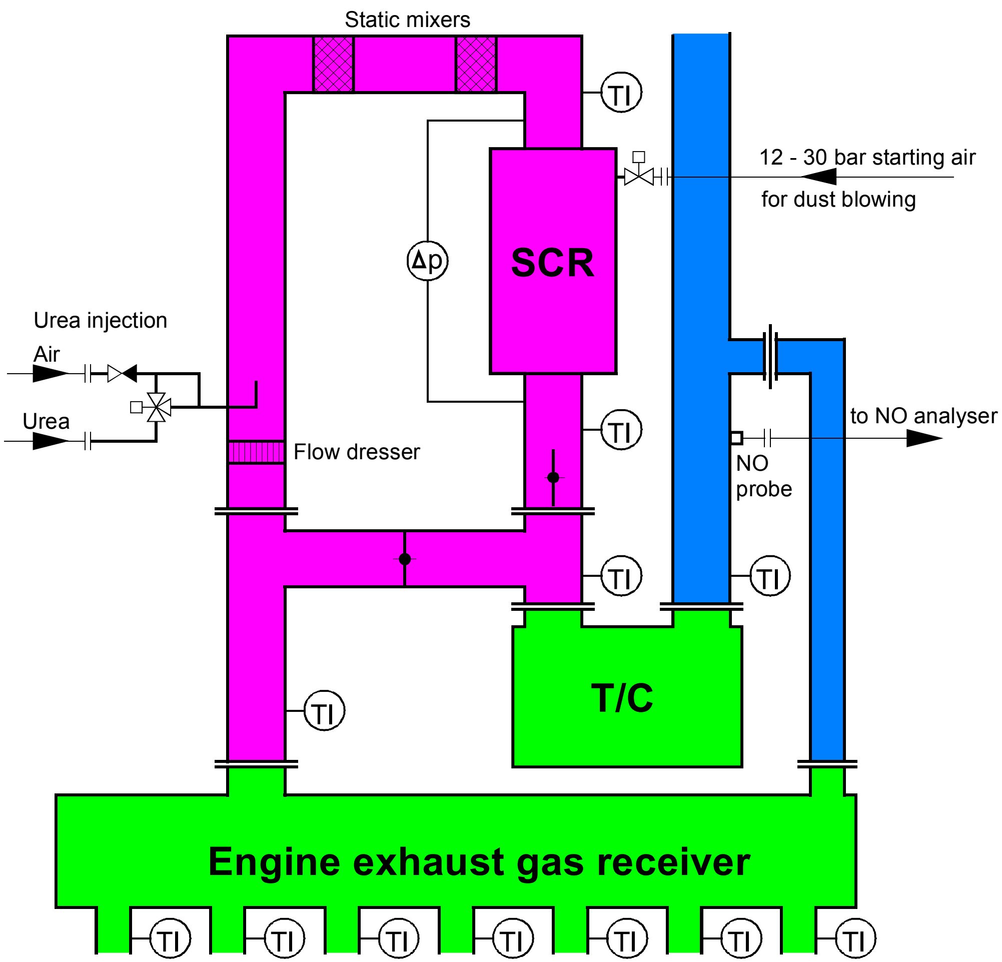
Application for Diesel Engines

The **optimum working temperature** to get a good efficiency out of the SCR system is **around 350 °C**.

As the exhaust gas temperatures of 2- and 4-stroke engines are different, the SCR system is located different:

- 2-stroke engine:
  SCR system to be placed before turbocharger
- 4-stroke engine:
  SCR system to be placed after turbocharger

Reference Installation: Pre-turbo SCR arrangement



As applied for Sulzer 7RTA52U engine on heavy fuel operation

3 x RO-RO vessels for Wagenborg Shipping B.V.

- Engine
- SCR system
- Shipyard piping

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$CO/CO_2/HC$

CO and HC emissions

- Low due to high O_2 concentrations and efficient combustion process
- Of no legislative concern yet
- Reduction of HC with minisac nozzle, reduced lub.oil consumption, minimization of “dead volumes” in the combustion space and ring groves

CO_2

- Function of the quantity of fuel burned
- No regulation yet, but discussed on IMO board
- Reduction: higher propulsion efficiency

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SO_X

- Derive directly from sulphur content of fuel
- Limited by IMO to 4.5% sulphur content of the fuel;
  SO_X emission control areas (Baltic Sea, North Sea): 1.5%
- Reduction measures: Higher propulsion efficiency, low sulphur fuel,
  (Exhaust gas cleaning $DeSO_X$ (wet scrubbers) not suitable)

The most applicable method to reduce SO_X is to run on low-sulphur-fuel. Desulphurisation of the bunkered fuel onboard or after-treatment of the exhaust gas is more expensive, requires additional space for the installation and the handling of the resulting waste products. Desulphurisation onboard nor after-treatment are not to be considered as viable methods at the moment at marine applications.

Smoke reduction measures

Aim: Reduce visible smoke

- Minisac nozzles (for 2-stroke engines; in development)
- Common rail
- Advanced injection timing (NO_X ↑)
- Increased scavenge air temp. (NO_X ↑)
- Fuel quality
- Lub.oil quality/quantity
- Exhaust gas cleaning: Not considered for marine applic. at the moment

Summary/Outlook

- Measures and certification procedures to comply with Annex VI NO_X limit introduced successfully ⇒ todays standard
- 'International' character of this regulation facilitates introduction and application
- To guarantee compliance during lifetime of the engine
⇒ parameter check method according to NO_X Technical Code (described in detail in the engine's Technical File)
- Measurements on board quite a challenge
⇒ Accuracy, repeatability (measurement of power, bsfc, emissions)
⇒ test cycle procedure (vessel out of service for several days)

Summary/Outlook

Different **new emission reducing technologies** are in development at the moment.

As partly only testbed results from one engine type/rating is available, it should be kept in mind that the emission reducing potential and operational behaviour when applying to different engine types, ratings, operational conditions, etc. might differ from the (measured) reference and therefore further modifications (design, engine control) and time (!) might be necessary to adapt the technology to different engine types. First estimations of the potential of a measure or first results must therefore be handled carefully till long-term and wide-range experience is available.